

Europäisches Patentamt

**European Patent Office** 

Office européen des brevets



(11) EP 0 731 597 A2

(12)

### **EUROPEAN PATENT APPLICATION**

(43) Date of publication: 11.09.1996 Bulletin 1996/37

(51) Int. Cl.<sup>6</sup>: **H04N 1/405** 

(21) Application number: 96102365.2

(22) Date of filing: 16.02.1996

(84) Designated Contracting States: **DE FR GB** 

(30) Priority: 21.02.1995 JP 57933/95

(71) Applicant: Dainippon Screen Mfg. Co., Ltd. Kamikyo-ku Kyoto 602 (JP)

(72) Inventors:

Sano, Hiroshi,
 c/o Dainippon Screen Mfg. Co., Ltd.
 Horikawa-dori, Kamikyo-ku, Kyoto (JP)

Hirawa, Takahide,
 c/o Dainippon Screen Mfg Co, Ltd
 Horikawa-dori, Kamikyo-ku, Kyoto (JP)

Nakamura, Yasunori,
 Dainippon Screen Mfg Co, Ltd
 Horikawa-dori, Kamikyo-ku, Kyoto (JP)

(74) Representative: WILHELMS, KILIAN & PARTNER Patentanwälte Eduard-Schmid-Strasse 2 81541 München (DE)

### (54) Method and apparatus for generating halftone image

(57) A plurality of correction look-up tables are prepared corresponding to offsets of halftone dot areas. An offset of a halftone dot area including the subject pixel is calculated, and a correction look-up table specified by the offset is selected in order to correct an input density value. Threshold values read out from an SPM (screen pattern memory) 130 may be corrected instead. Alternatively, a plurality of SPMs are prepared, each of which stores corrected threshold values corresponding to each offset, and an appropriate SPM is selected according to the offset. Accordingly, halftone dots are generated to faithfully reproduce a desired tone specified by multi-tone image data.

Description Tails promote the production of the second of

Field of the Invention of Consent is an earlier in the second of the first and second of the second

The present invention relates to a method of generation atting a halftone image based row multi-tione image datas and also to an apparatus for the same that both statistics in several transfer to be must at an

Description of the Related Artheoreu, some shinks. Se item.

The halftoning technique expresses the density of an image by a dot percention a great rate of a halftone) and dot. An arrangement of halftone dots in an halftone was image, is defined by a screen ruling (or a pitch of half-utone dots) and a screen angle (or an angle of the dot a tone dots) and a screen angle (or an angle of the dot a tone dots) and a screen angle (or an angle of the dot a tone dots) halftoning technique applies; an constant to screen ruling over the entire image, and thus the rough and ruling make the problem and the screen that ruling make the problem and the screen that

Incolor-printing technique, an original color image tham is separated into four primary colors to generate four: pai color eseparation dihalftone, images. The relationship as among the halftone dot arrangements of the four color user separations; that is, the relationship between the four is sets of the escreen; angle and the escreen; ruling, visualic extremely important in high-quality printing. Especially into a required that the screen angles of the four color septenda arations are exactly, set to predetermined values of beau and

There are two typical methods applied to generate sem halftone dots: Rational Tangent Method in which a tan- xoo' gent of screen angle θ (tanθ) is a rational number; and eatho Irrational Tangent Method in which an tangent of screen than angle θ is an irrational number of the Rational Tangent elds: Method does not allow the user to set an arbitrary. screen-ruling; but generates halftone images having a Hum predetermined screen ruling specified by a spreset(o) M threshold matrix. The Irrational Tangent Method, on the 140 other hand, can adjust the screen ruling by selectively have reading out some threshold values from acthreshold slots matrix while skipping others according to the screentrule modern according to the screentrule modern according to the screentrule and the screentr ing. Thus, the Irrational Tangent Method can set an arbitrary screen and an accurate screen angle by edas varying the way of reading out threshold values from anoma threshold;matrix.bns ir are tob enobled dose and his pricebs

Figs. 1(A) through 1(C) show a process of generat-tops ing halftone dots by the trrational Tangent Method Figure 1(A) shows a 128x128 matrix including threshold values in 50 in a range of 0 to 16383. A rhombic area on the centers of Fig. 1(A) is defined by the threshold values. To less not than a value (=8192) corresponding to an image density of 50%. When the entire halftone dot area consists of 32 128x128 pixels; all the threshold values in the matrix of 555. Fig. 1(A) are to be used in generating one halftone dot as a The typical process of generating a halftone image successively reads out threshold values from the threshold matrix, compares the read-out threshold values with the

multi-tone-image:data:to-determine on/off state:of pix-a-widels, and generates a halftone:dot based on the result of acceptance the comparison. For the image density-of 50%, for example, halftone:dots having the rhombic area shown in Fig. 1(A) are recorded.

The conventional algorithms to Method, howevery does not always reflect the exact density bas expressed by multi-tone image data on the dot percent or the halftone dot area rate. When the entire halftone dot area consists of 6x6 pixels according to a specified \*\*\* screen ruling, for example, 6x6 threshold values are 200 read out from the threshold matrix of Fig. 1(A) to be at compared, with multi-tone image data while other threshold values are skipped. Fig. 1(B) shows positions of threshold values read out from the matrix under such conditions, and Figs 1(C) shows the read-out threshold values... When the value of multi-tone image data is 8192, the pixels which have threshold values less than 81925 are rexposed to generate a shalftone dot. The name threshold values circled in Fig. 1(C) have values less 10% than 8192, and the pixels having these threshold values are recorded as shown by the solid circles in Fig. 1(B) to generate a halftone dot. The example of Fig. 1(B) includes d3 pixels of solid-circles, which means the dot and percent of 13/36=0:36 (36%). Since the value of the multi-tone image data (=8192) corresponds to the density of 50%, the dot given in Fig. 1(B) does not faithfully to a reproduce the tone level expressed by the multi-tone image:data::Like this/example: the Irrational Tangent Method may not accurately reproduce the dot percent corresponding to the tone level expressed by the multitone image data. Similar problem is also observed in the 1000 Rational/Tangent/Method: goitaeles de seeste am sebulone de conscred three, la mairiges according to the offiset,

SUMMARY: OF THE INVENTION to a congruence of the gradual of the school o

An object of the present invention is thus to generate halftone dots which faithfully reproduce a tone level the specified:by/multi-tone image data; editive entressional (of the The present invention is directed to a method of comparing multi-tone image data with a threshold value?" to generate a halftone-image signal representing any or on/offestate of each of pixels arranged in lattices on an Abb image plane, and forming a halftone dot in response to the the halftone image signal in each halftone dot area which is repeatedly arranged to form an array of halftone dot areas on the image plane. The method comprises the step of (a) correcting at least either of the multi-tone image data and the threshold value so that a halftone dot is formed in the each halftone dot area to have a desired halftone dot percent specified by the multi-tone image data? ( Milios rignos in ) voi entry or as

The above method compares corrected multi-tone image data with a threshold value or alternatively multi-tone image data with a corrected threshold value, thereby forming a halftone dof having a desired dot period cent corresponding to the multi-tone image data in each halftone dot area. This results in generating halftone

្នុងនេះ ប៉ុន្តែបានការាងមួយ គ្រឹងប្រែក្រវិន្ទិស សាលាសេខ

dots which: faithfully: reproduce a desired prone elevel furtispecified by the multi-tone image data. a separate to the separate

Referably, the step (a) includes the steps of (b) determining an offset for the each flafftone dot area including a subject pixel to be processed, as a function of a resolution of the pixels as well as a screen ruling and a screen angle which define the arrayof halftone dot areas on the image plane, the offset representing a deviation of a predetermined reference point of the each halftone dot area from the pixel lattices; and (c) correct ing at least either of the multi-tone image data and the streshold value according to the offset of the lattices.

Since the appropriate degree of correction depends and on the offset of the halftone dot area, the above steps and attain appropriate correction according to the offset as attains.

In a preferred embodiment of the present invention possible method further comprises the step of preparing a use plurality of correction look-upitables with respect to a \$2.60 plurality of combinations of the screen ruling, the screen \$2.60 angle, the resolution of the pixels, and the offset, the 2020 plurality of correction look-up tables being adaptable to next be used to perform the correcting at the step (c). Fure the there is the step (c) includes the stepsof: selecting one of 1920 the plurality of correction look-up tables according to the 2000 offset; and correcting one of the steplif-tone image data and the threshold value-based on the selected correction look-upstables.

In another embodiment, the step-(a) further some oper prises the step of preparing a plurality of corrected semi-threshold matrices with respect to a plurality of combinities nations of the screen ruling the screen angle, the respect to a plurality of combinities nations of the pixels; and the offset; and wherein the step shot (c) includes the steps of: selecting one of the plurality of ore corrected threshold matrices according to the offset; and reading out a corrected threshold matrix thus selected.

The desired halftone dot percent corresponding to-multi-tone image data; logis given by M(lo)/Mt, where deta M(lo) denotes the number of pixels to form the halftone deta dot in the each halftone dot area, and Mt denotes a total? 40 number of pixels in one halftone dot area. The step (a) made includes the step of correcting the multi-tone image of data to be greater than an M(lo)-th lowest value among to the Mt threshold values corresponding to Mt pixels existing parties in the each halftone dot area. If leaving eperm, show as

Alternatively, the desired halftone dot percent corresponding to multi-tone, image data to is given toy and M(lo)Mt, where M(lo) denotes the number of pixels to and form the halftone dottin the each halftone dottarea, and Mt denotes a total number of pixels in one halftone dot so area; and wherein the step (a) includes the step of correcting the lowest through an M(lo)-th lowest values among Mt threshold values corresponding to Mt pixels existing in the each halftone dot area to be less than the multi-tone image data loss too.

The present invention is also directed to an apparatus for comparing multi-tone image data with a threshold value to generate a halftone image signal representing an on/off state of each of pixels arranged

in lattices on an image plane, and forming a halftone dother in response to the halftone image signal in each halftone dot area which is repeatedly arranged to formean AS array of halftone dot areas on the image plane. The apparatus comprises: a threshold memory for storing left the threshold value representing a shape of a halftone dot according to an image density; and correction means for correcting at least leither of the multi-tone of the image data and the threshold value so that a halftone bus dot is formed in the each halftone dot area to have a desired halftone dot percent specified by the multi-tone seed image data.

In a preferred embodiment of the present invention,

the correction means includes: effect calculating means for determining an offset for the each halftone dot area including a subject pixel to be processed, as a function of a resolution of the pixels as well as a screen ruling and a screen angle which define the array of halftone dot areas on the image plane, the offset representing a deviation of a predetermined reference point of the each halftone dot area from the pixel lattices; and correction executing means for correcting at least either of the multi-tone image data and the threshold value according to the offset of a correction executing means for corrections executing means for preparing a local correction which the offset of a correction executing means for preparing a plurality of combinations of the screen with respect to a correction angle, their esolution to the pixels, and the offset, the other angle, their esolution to the pixels, and the offset, the other propagation and the offset, the other pixels, and the offset of the pixels.

angle, their esolution of the pixels, and the offset, the end plurality of correction took-up tables being adaptable to see the multi-tone image data; selection as means for selecting one of the plurality of correction look-up tables according to the offset calculated by the offset calculating means and means for correcting the inspending to the correction between the correction to see the correction of the correction to see the correction of the offset calculating means and means for correction to see the correction to see the correction of the

The destredshalltone dot percent corresponding to the multi-tope image data 4000 given by M(10)/Mt; where 4000 M(10) denotes the number of pixels to form the halftone bead dot institute actual to the dot area and Mtdenotes a total 4900 number of pixels in one halftone dot area. The looking value table preparation means includes means for obtaining bead corrected multi-tone image data is increased of the mage data. In the looking of the looking among that threshold value corresponding to Mt pixels among that threshold value corresponding to Mt pixels are existing in the each halftone dot area; and means for post registering relations between the multi-tone image data. In the corrected multi-tone image data.

In another embediment; the Acorrection executing an ensemble substantial experiments for a preparing application of the screen rule of the offset, the plurality of correction took-up tables being adaptable to be used to correct the threshold value; and selection means for selecting order of the plurality of correct of the plurality of correct order to the offset calculated

by the offset calculating means; and means for correct-fileing the threshold value based on the correction look-up for table selected by the selection means.

The desired halftone dot percent corresponding to a multi-tone image data to is given by M(lo)/Mt, where so M(lo) denotes the number of pixels to form the halftone dot in the each halftone dot area, and Mt denotes a total an umber of pixels in one halftone dot area. The look-up so table preparation means includes: means for determining corrected threshold values by setting the lowest and through an M(lo)-th lowest values among Mt threshold values corresponding to Mt pixels existing in the each halftone dot area to be less than the multi-tone image data los and the corrected threshold was value into the plurality of correction look-up tables:

In another aspects of the present invention the apparatus- comprises: coffset: calculating emeans for this determining an offset for the each thatftone dot area and including a subject pixel to be processed; as a function 20 of a resolution of the pixels as well as a screen ruling (90) and a screen angle which define the array of halftone ment dot areas on the image plane; the offset representing attach deviation of a predetermined reference point of the each 105 halftone dot area from the pixel lattices matrix preparate 125 tion means for preparing a plurality of corrected threshald an old matrices for a plurality of combinations of the screen #isr ruling, the screen angle, the resolution of the pixels, and the offset, the plurality of corrected threshold-matrices igns being stored in the threshold memory and adaptable to aso be compared with the multi-tone image data-so that analo halftone dot is formed in the each halftone dot area to iouz have a desired halftone-dot-percent specified by aheliang multi-tone image data selection means for selecting one of the plurality of corrected threshold matrices iss according to the offset calculated by the offset calculateers ing means means for reading out a corrected threshold the value from the threshold memory selected by the selections tion means; and comparison means for comparing the Seas corrected threshold value read out from the selected corrected threshold matrix with the multi-tone image ball data, thereby generating the halftone image signal lame aff.

The desired halftone dot percent corresponding to the multi-tone image data-loais given by M(lo)/Mt; where does M(lo) denotes the number of pixels to form the halftone dot in the each halftone dot area; and Mt denotes a total number of pixels in one halftone dot area. The matrix preparation means comprises means for correcting the lowest through an M(lo)-th lowest values among Mt threshold values corresponding to Mt pixels existing in 500 the each halftone dot area to be less than the multi-tone and image data lo, to thereby obtain corrected threshold values to be stored in the plurality of corrected threshold matrices.

These and other objects, features, aspects, and 555 advantages of the present invention will become more apparent from the following detailed description of the preferred embodiments with the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1(A) through 1(C) show a process of generating dots by the Irrational Tangent Method;
Figs. 2(A) through 2(C) show a fundamental idea of correcting image data in the present invention;
Fig. 3 shows an exemplified relationship between halftone dot areas and pixel positions in an image plane;
Fig. 4 shows the relationship between halftone dot areas and pixel positions with the varied screen angle 6.

Fig. 5 shows the relationship between halftone dot areas and pixel positions with the varied screen ruling (LPI);

Fig. 6-shows the relationship between halftone dot areas and pixel positions with the varied resolution (DPI) of the output device.

Fig. 7-shows coordinates assignable to a reference point in one halftone dof area.

Fig. 8 shows the positions of threshold values referred to at the division coordinates (i,j); fig. 2 Fig. 9 is a flowchart showing a routine of preparing screen gradation tables.

Figs. 10 his a flowchart showing details of the processing executed at step S5 in the flowchart of Figs. 12 at all a state of S12.15 grants a state of S12.15 grants a state of S12.15 grants are state of S12.15 grants as a stat

Fig. 11 is a block diagram illustrating the structure of a halftone image recording system for generating halftone images embodying the present invention; Fig. 12 shows a primary scanning direction V and a secondary scanning direction U on the photosensitive film and on about 20 many 26 many 2

Fig.-13 is a flowchart showing an operation of the halftone image recording system of the embodi-

Fig. 14 is a block diagram illustrating functions of the screening process unit 116; and the screening

Fig. 15 shows a correction curve prepared when the input density value to and the corrected density value to are set as data of different bit numbers.

Fig. 16 is a flowchart showing details of the processing executed at step \$23 in the flowchart of Fig. 13. Short are the fig. 13. Short at the processing executed at step \$23 in the flowchart of Fig. 13.

Figs. 17(A) and 17(B) show the halftone dot area coordinates (Xi,Yi) and the SPM address (Xd, Vd) with respect to the screen coordinates (X,Y);

Fig. 18 shows an update of the halftone dot area coordinates (Xi,Yi) with an update of the beam spot position;

Fig. 19 shows the actual procedure executed at step S34 for determining the division coordinates

Fig. 20 is a block diagram illustrating another structure of the screening process unit and screen pattern memory;

Fig. 21 is a block diagram illustrating still another structure of the screening process unit and screen pattern memory; and

Fig. 22 shows a correction curve including a non-198 linear relationship between the input density value and the number of pixels to be exposed; (A) = 31.5

# DESCRIPTION OF THE PREFERRED EMBODIMENT

## A. Fundamental Idea of Correcting Image Data a First

Figs. 2(A) through 2(C) show a fundamental idea of correcting image data in the present invention. The left part of Fig. 2(A) is a graph with input image data (input density value) to as abscissa and the number of pixels to be exposed as ordinate. In the description hereof, the term pixel represents a smallest recording unit on an output device used for recording halftone images. Singe the output device applied herein typically utilizes a light beam for recording halftone images, each pixel on the output device may hereinafter be referred to as a beam spot of the term inumber of pixels to be exposed in a halftone dot area is synonymous with adoth percent. Multistone image data thereby image and the value of multistone image data thereby implies density value of multistone image data thereby implies density value.

In order to reproduce the density of an image faithfully the number of pixels to be exposed should be proportional to the input density value to representing the image density. Fig. 2(B) shows the pixels to be exposed: when an input density value to (=8192) is used without any correction; this is identical with the drawing of Fig. 1(B). One method of the present invention corrects the 30 input density value to as shown in Fig. 2(A) to adjust the number of pixels to be exposed in For the input density value to of 8192 which corresponds to the image density sity of 50%, for example the multitone image data is corrected to realize 50 dot percent in each halftone dot- 35 area. When the multi-tone image data is corrected to become a corrected density value to of 8900; for example ple, the number of pixels with threshold values less than: 8900 (see Fig. 1(C)) will be equal to 18 as shown in Fig. 2(C). The number of pixels to be exposed by the corn 40 rected density value ic is thus equal to 18, which exactly reproduce the image density of 50% wolf a 2000 per

The positions of threshold values referred to in a threshold matrix are varied with a screen angle 0 and a: screen ruling Rh (line per inch (LPI)) of a halftone image 45 of concern and a resolution Rd (dot per inch (DRI)) of an output device applied, such as a record scanner. Fig. 3. shows an example of halftone dot areas applicable to an image plane. In the drawing of Fig. 3, intersections of smaller square lattices represent positions of beam, 50 spots in the output device, and larger square lattices: inclined by the angle of 0 specify boundaries of halftone dot areas. One threshold matrix is applied to each halftone dot area specified by a larger square lattice, and threshold values corresponding to the positions of intersections of the smaller square lattices are read out from the threshold matrix, and compared with multi-tone image data. In the description hereafter, the square lattices for defining positions of beam spots are referred to

as beam lattices' and those for specifying boundaries of halftone dot areas ase'screen-tattices. The pitch of wor beam lattices is equal to the reciprocal of the resolutions of the beam lattices is equal to the reciprocal of the resolutions of the putput device, whereas the pitch of screen at tices is equal to the reciprocal of the screen ruling Bholm, and the description, and yellow coordinates of beam lattices, (hereinaften to express the specifinates of beam lattices, (hereinaften to coordinate eystem to express the coordinates of threshold of values in the threshold matrix (hereinaften referred to as screen coordinate system).

Theefour halftone doteareas illustrated in Fig. 3 45 include beam spots at different positions. The upper-left "190" vertex of each halftone dot area denotes a freference and points and adeviation of the reference point in each halftone dot area from the closest upper-left point of the Advanced corresponding speam stattices (shown by broken-line) arrows in the drawing) represents an offset of the halftone dotrarea or 'dotroffset'. The four halftone dot areas said shown in Fig. 3: respectively have different dot offsets OF1 through OF4. Any two halftone dot/areas having identical, dot offsets; include beam: spots; at identical and positions. Anyetyo halftone idotrareas having different. dot offsetseonthercontrary, include beam spots at different positions. The characteristics of the correction curve see: as shown in Fig. 2(A) thus depends on the offset of the tridignations for a duratity of combinations cashs tob-spotlan

Figs 4-shows ranother, example, where the screen plant angle 9-is different from that of Fig. 13. Ascan be clearly a structure of the companies make tween Figs. 13 rand 14) raphed change in screen angle (6) varies if the positions of beam of the spots included fine exists that fit one dot area; that his, the will in positions of threshold values referred to had be used an exist.

Fig. 5 stowastill another example where the screen is the ruling. A hije different, from that ob Fig. 3 is the smaller and screens whing. By as writte example of Fig. 5 denlarges a too each halftone; dot area and accordingly increases their granumbes of beam spots included in reach halftone dot down area. And principal nor shape most is those the conservation area. Fig. 6 shows another example where the resolution area. Bd of the putput device as different from that of Fig. 3 is not. The smaller resolution and of the output device as time example of Fig. 6 results down a rougher pitch of the eart spots, thereby, decreasing the number of beam spots that included in each halftone dot area.

The positions of threshold values referred to inseath in the halftone dot area are thus varied with the offset of the first halftone dot area, the sorgen angle of the screen ruling to a Rh, and the resolution Rd of the coutput device. These est will characteristic values determine the characteristics of seint the correction curve as shown in Fige 2(A). So that does est the collection curve as shown in Fige 2(A). So that does est the collection of the correction of the correct

Before describing the method of determining a cord? rection curve, a possible value range for the offset of the mode halftone dot area is explained first. As described previously along with Fig. 3, the offset of each halftone dot be a area determines the positions of threshold values are

referred to in the halftone dot area. Restricting the possible value range for the offset of the halftone dot area " and to a number of predetermined values will result in restriction of the number of required correction curves. Fig. 7 shows local coordinates assignable to a reference 5: point Pref in a certain halftone dot area (the reference point is the upper-left point of the certain halftone dot area in this embodiment). Lattice points expressed by solid circles in the drawing of Fig. 7 represent the positions of beam spots (points of exposure) on the output -10 device, wherein the pitch of beam spots is equal to ..... 1/Rd. In this embodiment, the pitch of beam spots mod (hereinafter may be referred to as pixel pitch) is divided at the into N equal parts, and intersections of NxN lattices are set as permissible positions for the reference point Prefigure within the small area defined by the four beam spots. In guo the example of Fig. 7, N is equal to 6, and therefore 36 positions expressed by coordinates (i,j), where i=0 to 5,00 g and j=0 to 5, are set as the candidates of the reference point Prefaithe dot offset OF is given as a vector from 20 the position of the closest beam spot existing on the dead upper-left of the subject-halftone dot, area to the refers 159 ence point Rref. of the subject halftone dot area. The NxN positions assignable to the reference point Prefute accordingly give different values to the dot offset OF 32 1125

In the description, the coordinates (i,j) prepresenting that the candidates of the reference point. Prefaire referred to naxe as division a coordinates (i,j) the Theoldoth offset. OR: brise expressed by the junit of distance (inch): is requal to smooth (i/Rd,j/Rd) a incidentally evalues to the other than the division and coordinates (i,j) or the distance (i/Rd,j/Rd) of the dot offset or the top of the NxN dot offset values on a prince or set or the test.

Figs://8/rshows.cthes/positions.cof-threshold. values/referred to: The positions of threshold values/referred to: The positions of threshold values/referred to: as in each halftone dot/area/(that is) the positions of beam/uppl spots) are determined by the division coordinates (i,j)/of of the dot offset QF: threscreen ruling Rhythescreen angle 222 the dot offset QF: threscreen ruling Rhythescreen angle 222 to, and the output resolution Rd. Since there are shall side sets of possible division coordinates (i,j) for the dot off-sultoset OF, NxN: correction receives are required for each combination of the screen ruling Rhythe screen angle 6/8 9/3 and the output resolution Rd. so yields a set close 6/1 find

Ingthis embodiment, Hook-up tables are used forth a realizing the correction curves as shown in Fig. 2(A). his tast the description hereafter, the look-up table may be referred to as correction look-up table on screen gradation table to A memory for storing a threshold matrix corresponding to one halftone dot area is referred to as a screen pattern memory for SPM; co is seek to enough disco

Fig. 9 is a flowchart showing a routine of preparing screen gradation tables. At step S1 the values of the division coordinates (i,j) are initialized to (0,0). The program then goes to step S2 to determine the distance (i/Rd.j/Rd) of the dot offset OF at the division coordinates (ijj). All look-up values included in the halftone dot area specified by the distance of the dot offset OF (that is, threshold values at the positions expressed by the black circles in Fig. 8) are read out from a screen pat-

tern mémory catistée S3: Addresses of the look-up val- 8:05 ues are détermined from the distance (i/Rd,j/Rd) of thé 8:05 dot offset «OF pither screen ruling Rh, and the screen en angle 0.9mb of 300 ums.

The program then proceeds to step S4, at which all the look-up values read at step S3 are sorted in the ascending-order. When the look-up values include 36 threshold values shown in Fig. 1(C), for example, the 36 threshold values are rearranged in the order of 20, 40, 375, 60, 374, and 16382

At step S5, a corrected density value is determined for each input density value. Fig: 10 is a flowchart show- ing details of the processing executed at step S5 in the flowchart of Fig: 9::At step S11, the input density value is initialized to zero. The program then goes to step S12; at which a required number of pixels M to be exposed for the faithful reproduction of the input density value is calculated according to the following equation (1):

where Mt denotes a total number of pixels in the half-sit tone dot area, lo an input density value, and lmax a density range. The density range Imax is synonymous with the maximum value of the input density value lo. When the input density value lo is expressed as 8-bit data; for example, Imax=255. The total number of pixels Mt is equal to the total number of look-up values read at step S3 in the flowchart of Fig. 9. The above equation (1) determines the required number of pixels M to be exposed by multiplying the total number of pixels in the halftone dot area by the density percentages.

where:TD:denotes a threshold value, and Ic denotes a corrected density value. A responsible of the second and t

Thus, selecting the (M+1)-th look-up value as the corrected density value ic will cause M pieces of beam spots to be exposed in this halftone dot area. This gives a dot percent of (M/Mt), which faithfully expresses the tone level of the input density value to.

The program then goes to step \$14, at which the corrected density value ic is written into the correction look-up table while using the input density value to as an address. This completes the process for one input density value to.

After incrementing the input density value to by one at step S15, the program returns to step S12 to repeat the process of steps S12 through S14 until the input density value to reaches the maximum lmax at step

S16. Executing the process of steps.S32athrough:S15 herefor all the input density values to inharrange of 0-to that he gives; one screen gradation table representing the characteristics of a correction curve with respect to one dot good fiset (i,j), the screen of the process of the process

When the input density value to reaches:the maximum lmax at step \$16, the program-goes to steps \$6 put through \$9 in the flowchart of Figs.9 to increment it or it is by one until both j and i reach the value. No The process and of steps \$2 through \$5 are executed for all the division and coordinates (i,j), so that NxN sets of screen gradation tables were prepared, respectively for NxN dot offsets and (i/Rd,i/Rd) (wherein, 0si,j<N). A table number white guidance with of identification. The table number Nt. is given; for example to leach screen gradation, table for the purpose wolf of identification. The table number Nt. is given; for example 2 during the purpose wolf of identification. The table number Nt. is given; for example 2 during the purpose wolf of identification. The table number Nt. is given; for example 2 during the purpose wolf of identification. The table number Nt. is given; for example 2 during the purpose with the purpose with the purpose of the purpos

In this case, table numbers in a range of 0 to (NxN- 20 1) are assigned to the NxN sets of screen gradation tables. The distalking its rediction leading its section of the set of the set

The process of Figs. 9 and 10 cwill provide NxNe not pieces of screen gradation tables for each combination: the of the sereen ruling. Rhythe screen angle 0, land the outh e25 put resolution. Rds as bessenous a pentsy there a tronient at the figure to recover sint entire 200 count element. C. Structure and Operation of Apparatus in store at the laws of the series are some entire country of the series of t

Fig. 11 is a block diagram illustrating the structure of structure of a halftone image recording system applied as an outcome put device for generating halftone images embodying that the present invention. The halftone image recording system includes a screening processor; 100; an; output gate interface unit-200, and an output process unit-300. The ulas screening processor 100 includes to CPU trocentral toosa processing unit) 110, a RAM (random access memory) 2/02 120, an SPM (screen pattern/memory), 130, a hard disk; pers 140, and an output port 150. Multi-tone image data, which are subjected to the screening process, are stored in the hard disk 140. In the process of generating halftone images, a beam position pulse signal Sb representing an update timing of the beam spot in the output process unit 300 is transmitted from the output process with unit 300 to the screening processor 100. The screening 45 processor 100 executes the screening process synchronously with the beam position pulse signal Sb. The term Tra 'screening' or 'screening process' in the description represents a process of generating a binary halftone image signal from multi-tone image data and a contract to leave of 50

The GRU, 110 executes software programs stored in the RAM 120 to realize the functions of a look-up table preparation unit 112, an input/output control unit 114, and a screening process unit 116. The look-up table preparation unit 112 executes the process of preparing screen gradation tables according to the routine of Figs. 9 and 10. The screening process unit 116 determines on/of of each beam spot according to the inequal-

CASE TO RESTRICT A 9 D.

ities (2a) and (2b) given above to generate a binary halftone image signal RS:

The halftone image signal RS generated in the screening processor 100 is supplied to the output process unit 300 via the output port 150 of the screening processor 100 and the output interface unit 200. The output process unit 300 records a halftone image on a photosensitive film in response to the halftone image signal RS. Fig. 12 shows a primary scanning direction V and a secondary scanning direction U on the photosensitive film. The secondary scanning direction U and the primary scanning direction V and the primary scanning direction V are identical with the coordinates U and V in the beam coordinate system (Fig. 3).

Fig. 43 is a flowchart showing an operation of the screening processor 100. When the program enters the routine, initialization of the screening processor 100 is executed to set the screen ruling Rh and the screen angle 6 of a resulting halftone image and the resolution Rd of the output device at step \$20. The program then The goes to step S21; at which screen gradation tables are """ prepared for the combination of preset values (Rh. 0, Rd) according to the procedure of Figs. 9 and 10. The screen gradation tables thus prepared are stored in the RAMP120.7 In Paccordance with one preferable application, screen gradation tables are prepared in advance for typical combinations of preset values (Rh, 0, Rd) (for reset values) example-{Rhe175:LiP,9±0,15,45,75, Rd=4,090:DRI}):08(7. and stored in the hard disk 140. Screen gradation tables : \*\*\* corresponding to the input combination of preset values at 12.5 {Rh, 00Rd};are read from the hard:disk:140 and written (1981) into the RAWet20 for use in the screening process. This has structure allows the processing of step \$21 to be omit? 2.198 ted in the screening processis value of the MxN and the end party and the MxN and the end party and th

Figs.44 is asblock diagram/illustrating functions of the screening procession to unit 116 includes a density correcting anit 362 partable to a number selecting unit 164, an SPM address calculating unit 166, and an on/off determining unit 168 modernt grantless.

The units 162s:164; and 166 correspond to the correspond to the correspond to the correction means for correcting the input density value. The corresponds to the confiser calculating means; for determining am offset for reacting the halftone dot area of concern, and the table number send selecting unit 164 corresponds to the selection means if for selecting a screen gradation table according to the coffset on the coffset o

The SPM address calculating unit 166 calculates an address (Xd, Yd); of the screen pattern memory (130 for the beam spot) that is under the screening process of the beam spot) in response to the beam position pulse signal Sb transmitter ted from the output process unit 300; and supplies the world

FT ON STAR ON THE

address (Xd,Yd) to the screen pattern memory: 130. A threshold value (look-up value) TD corresponding to the address (Xd, Yd) is read out from the screen patternes. memory 130. In the example of Fig. 14 look-up values. TD are 14-bit digital data. The SPM address calculating 15. unit 166 further calculates division coordinates (i,j) representing an offset of the halftone dot area including thesupo subject beam spot, and supplies the division coordinates (i,j) to the table number selecting unit 164. Details of the processing executed in the SPM address calculating unit ,166 will be described later. V. 1, 14 41

The table number selecting unit 164 determines the table number. Nt corresponding to the division coordinately nates (i,j) according to the equation (3) given above. The density correcting unit 162 selects one screen gradults dation table according to the table-number Nt given by it at the table number selecting unit 164, and registers the well input density value to at the address of the selected party table so as to read the corresponding corrected density had value lc. In the example of Fig. 14, the input density. 20 value logis 8-bit data, while the corrected density value same Ic is 14-bit data as is the threshold values TD-read out area from the screen pattern memory 130. The input density some value to and the corrected density value to may have dif-" and the ferent bit numbers as seen in this example c Fig. 150 250 shows: a correction curve prepared when the input/den-sultav sity value to and the corrected density value to have difensiti ferent bit numbers. The correction curve of Fig. 45 is 181400 substantially-identical-with-that-of-Fig. 2(A):-but-with-adifferent scale on abscissa in the left-hand graph repres gate senting the relationship between the input density value hado lo and the number of pixels to be exposed) such a re yet best

The corrected density-value losobtained in the idensity value losobtained in the identity value losobtained sity correcting unit 462 is given to the on/off determining analy unit 168; which compares the corrected density value to elast with the threshold value TD cread tout from the screen enter pattern/memorye/130: and/generates: at binary/halftone sulsy image\_signal RS according to the inequalities (2a) and with (2b) given above. The halftone image signal aRS athus fuces generated is supplied to the coutput process unit 300 viail 40 the output porto150 and the output interface unit 2080 4 se (Fig. 1st) A halftone image is recorded on a photosensi-setma tive film incresponse to the halftone image signal/RS. RETE TOO

After the halftone images signal RS for one beam a will spot is generated at step S23 in/the flowchart of Fig. 43) 145.1 the program goes to step \$24; at which it is determined shot whether the processing is a completed for the whole of no range of the primary scanning direction V (Fig. 12). When not completed, the program returns to step \$22%. 3 to execute the process of steps S22 and S23 for a next 50 beam spot adjoining in the primary scanning direction V.5 When the processing is completed for the whole range of the of the primary scanning direction V, on the contrary, the contrary, program process to step S25 to execute the processing in the state of the processing in the processing for a next primary-scanning line. At step \$26, it is determined-whethers the processing is completed for the whole ranger of the secondary; scanning direction it. When not completed, the program returns to step S22 167 when the position of exposure is varied by a pitch ΔV of to repeat the process of steps \$23 through \$24 \$ 100 for

Repeating the process of steps S22 through S26 implements the generation of halftone image signals RS for all the range of the image, and records a resulting half- 6th tone image on a photosensitive film.

In this embodiment, a plurality of screen gradation tables are prepared according to: the division coordinates (i,j) of the dot offset OF, the screen ruling Rh, and the screen angle  $\theta$  of a resulting halftone image; and the resolution. Rdbof the output device. The input density value to is corrected according to one of the plurality of the screen gradation tables thus prepared. The corrected density value ic is compared with the threshold value TD read out from the screen pattern memory 130. A halftone image signal RS is then generated on the basis of the comparison to faithfully reproduce the tone level expressed by the input density value to. The screen gradation tables can be prepared prior to generating a halftone image signal RS from the multi-tone image data (input density value to) as shown in Fig. 13? Thus this embodiment generates a halftone age which faithfully reproduces the tone level expressed by the input density value to without increasing the process time for generating the halftone image signal RS from the input density value to a second an arrived by the mobile of given see as tee whose square ada of the equencies will as

D. Details of the Process of Generating a Halftone Image Signal for Each Beam Spot of the graduation and the same that yri chadichook is shi de la eron bha i this i Nilliud vi anib

Fig. 16 is a flowchart showing details of the processing executed at step \$23 in the flowchart of Fig. 13. The process of step S23 shown in Fig. 16 is executed every time when one pulse of the beam position pulse signal Sb is transmitted from the output process unit 300 (Fig. 11) to the SPM address calculating unit 166 shown in Fig. 14. วจะ ตัวสะสไซล ดองคนักของ (Xi, Yi)

At step S31, the screening process unit 116 updates screen coordinates (X,Y) in the primary scan ning direction V and determines an SPM address (Xd, Yd) and halftone dot area coordinates (Xi, Yi). Fig. 17(A) shows the halftone dot area coordinates (Xi,Yi), whereas Fig. 17(B) shows the SPM address (Xd, Yd). The halftone dot area coordinates (Xi,Yi) shown in Fig. 17(A) represent the position of each halftone dot area. The halftone dot area coordinates (Xi, Yi) consist of the integral parts of the screen coordinates (X,Y): Fig. 17(B) is an enlarged view illustrating a halftone dot area defined by the halftone dot area coordinates (Xi, Yi)=(1,2). The SPM address (Xd, Yd) shown in Fig. 17(B) represents the position within one halftone dot area (SPM area). The SPM address (Xd,Yd) consist of 5/13 the decimal parts of the screen coordinates (X, Y).

The output process unit 300 records a halftone image by exposing a recording medium, such as a photosensitive film to a light beam running in the primary scanning direction V. The expression updating screen coordinates (X,Y) in the primary scanning direction V implies determination of the screen coordinates (X,Y) beam spots in the primary scanning direction V.

55 °

Conversion of the beam-spot coordinates (UtV) ito 19.15 the screen coordinates (X,Y) is expressed in general by 🔞 " the equations (4a) and (4b) given below: eth to e paster

is conditionally appropriate ης τημετώς X = U τροκθιτ.Μιτsinθer .Δισάπε (4a) τι σ that is are prepared that it is at the --Y = U • sinθ + V • cosθ เกอบ คศา ฮิ(4b)) เลาลา 631211 85 41 61 e peda.

By substituting U=m · \( \Delta U \) and \( V = n \* \( \Delta V \); the equation is tions (4a) and 4(b) are rewritten as: a patociar of an all auto . gest . T soreen dictroling g<sub>i</sub> s<sub>by</sub> X = m·ΔU •cosθ -m •ΔVm sinθ c. εu(5a) tiensb the see west most the pae CV \$ 555 W 11 ains, Y₁= m • ΔU sinθ + n • ΔV∂ cosθ no egu(5b) ruftis. lev licht schron en lein der bei de lein der de leine de wherein m and n are integers, and AU and AV representations the pitch of beam spots in the secondary scanning and direction and the primary scanning direction (Fig. 417) at 14 hor

Since the secondary scanning-coordinate Uthas abont fixed value on the entirety of one scanning line in the prixed 20 mary scanning direction. Vithe integer m in the equationer tions (5a) and (5b) is constant/on each scanning lines/ viiz Updating the screen coordinates (X-Y) in the primary at see scanning direction V only varies the integer n in the sectionals ond term of the right-hand side of the equations (5a) 25 and (5b) by one, Progress of the beam spot by one in 3 the primary scanning direction Videcreases the X cooregam dinate by  $\Delta V \cdot \sin \theta$  and increases the Y coordinate by 트를 is a flowchart showlerylggibroops θago • VΔ

At step S31 of Fig. 16, screen coordinates (X; Y) are 303 calculated according to the equations (5a) and (5b) T.81 given above, and the decimal parts of the screen coor-betto dinates (X,Y) are used as the SPM address (Xd,Yd) estud while the integral parts thereof are adopted as the half-8 film tone dot area coordinates (Xi,Yi). 185 shown in Fig. 14

The updating process of the secondary scanning coordinate U\_at\_step (\$25 in the flowchart, of Fig. 13 telegraincrements-the integer main the first term of the right- pan hand side of the above equations (5a) and (5b) by one (150)

At step \$32 in the flowchart of Fig. 16, a threshold: 40 value TD at the updated SPM address (Xd;Yd) is read andw out from the screen pattern memory 130 (Fig. 14) notife the first

The program then proceeds to step \$33, at which it 🙏 🏋 is determined whether the halftone dot area coordinates at T (Xi, Yi) are revised by the calculation of step S31. Fig.:18 45: shows revision of the halftone dot area coordinates (Xi, Yi) caused by an update of the beam spot position. The halftone dot area coordinates (Xi,Yi) are revised when the beam spot position is shifted from one halftone dot area to an adjoining halftone dot area. In the example of Fig. 18, the halftone dot area coordinates = + (Xi, Yi) are revised from (1,2) to (0,2). Since different correction, curves are applied to different halftone dot: areas, the table number (i.i) is recalculated for the new halftone dot area including the subject beam spot at a 55,8 step \$34. The industrial of the machine of the set of the control of the control

Fig. 19 shows the actual procedure-executed at step S34 for determining the division coordinates (i,j). The halftone dot area coordinates (Xi,Yi) are identical with the screen coordinates (X,Y) of the reference point was (the upper-left point) Pref of the halftone dot area according to their definitions. At step S34, the halftone 10000 dot area coordinates (XI,YI) are converted to coordinates in the U-V coordinate system, that is, coordinates (Uref, Vref) of the reference point Pref, according to the area equations (6a) and (6b) given below: 112 tear one promotes

אים סמכ ו הצאום פונו פרול מילוסקער ייחה מאין. המשפל משוכנו West Wref XP cose + YF sine Late (6a) of the Brofisson Liexeouted in the BEM audining the Vref = -Xi •'ŝinθ'¥ Yi •coŝθ (\*\*\*) (6b) (6b) The fact of moderael condition for detaining the

wherein :Urefrand Wreff are avalues including decimal and the parts.-The integral parts of the coordinates (Uref, Vref) represent the coordinates of the upper-left pixel closest to the reference point Pref, whereas the desimal parts with thereof represent the offset OF of the halftone dot area (Fig. de) in The idecimal parts of the coordinates (Uref, in a Vref) are then substituted as the division coordinates (iii) into the equation (3). This process determines the table number.NtaThe numberm of the lower bits representing the decimal parts of the coordinates (Uref, Vref) may be set to be an integer satisfying the equation and N=2<sup>m</sup>, where N denotes a number of divisions of the off-€ all N set incone scanning direction (Figs 7) This allows the value of the lower bits representing the decimal parts of vices the coordinates (Uref, Vief) to be directly used as the View division coordinates (ii) a correction of (ii) eathingood repisivib

After the determination of the table number Nt at 4000 step S34: the program proceeds to step S35 in the flow step chart of Eig.of 6; at which a screen gradation table special as ified by the table number: Nt-is: selected: (Fig: 114), (and (iii)) the corrected density value locorresponding to the input density value loss read outstrom the screen gradation with table thus selected. At step \$36, the corrected density in the value le is compared with the look-up value on threshold him value gread sout, from the screen pattern memory 130 1915 and generates: a inhalftone simage; signal > RS from the parts result of the comparison emitted and levode near (22) or In the process of Fig. 16, a screen gradation table is 40% selected for each shalftone dot area line luding the pixel 6 55 under processing according to the offset of the halftone (2003) dot area, and corrects the input density value based on Eq. 6. the selected screen gradation table. This gives the halftone image signals RS, which: faithfully reproduces the 1942 tone level expressed by the input density value; based of 900 on the offset of each halftone dot area is a soon great in a factor of rative of the primary scanning cirector in (Fig. 12)

to prelich a directioders of steps 522 and 323 to 1 had Fig. 20 is:a block diagram illustrating another struc- 1950 ture of the screening process unit and screen pattern 🚳 📣 memory; The structure of Fig. 20 includes an SPM core and icrecting unit 170 in place of the density correcting unit 1994 162 of Fig. 14: The SPM correcting unit (170) corrects 11:50 each threshold value ID read out from the screen pattern memory 130 to generate a corrected threshold value TDc. The on/off determining unit d68 compares at 5 the corrected threshold values TDc with the input den-

ser E. Other/Embodiments en mangand end (heretomico fon her W

.133)

50,0

15

sity value lo and generates a halftone image signal RS based on the result of the comparison. Like the density correcting unit 162 shown in Fig. 14, the SPM correcting unit 170 includes NxN correction tables corresponding to the respective division coordinates (i.j) of dot offsets. One correction table is selected according to the table number Nt determined by the table number selecting unit 164. Each correction table included in the SPM correcting unit 170 is a look-up table, from which an 8-bit corrected threshold value TDc is read out while using each 14-bit threshold value TD read out from the screen pattern memory 130 as an address. The contents of the correction tables are predetermined to attain the faithful reproduction of the tone level expressed by the input density value lo. In the structure of Fig. 20, the look-up table preparation unit 112 calculates the contents of each correction table included in the SPM correcting unit 170 and writes the calculated contents into the RAM 120 at step S21 in the flowchart of Fig. 13.

The units 164, 166, and 170 correspond to the core rection means for correcting threshold values

Correction of threshold values TD, which is read out: from the screen pattern memory 130 according to the dot offset as in the case of Fig. 20, gives a substantially? identical result to that attained by the structure of correcting the input density value low (Figs 14) as not enoticed

Fig. 21 is a block diagram illustrating still another structure of the screening process unit and screen pattern memory. The structure of Fig. 21 includes an SRM number selecting unit 180 in place of the table number 30 selecting-unit-164 and an SPM unit-190 in place of the screen pattern memory 130 and the SPM correcting: unit 170 of Fig. 20. The SPM unit 190 includes NxN screen pattern memories corresponding to NxN dot off A sets. Each screen pattern memory included in the SPMv unit 190 is a RAM in which corrected threshold-values-TDc corresponding to each dot offset are written at the respective look-up positions. Arbitrary values can be assigned to the threshold values which are not to be looked up. The corrected threshold values TDc read out: from the SPM unit, 190 are identical with those output. from the SPM correcting unit 170 in the embodiment shown in Fig. 20. In the structure of Fig. 21. the look-up/ table preparation units/1/12/calculates the contents of each screen; pattern; memory; included in: the SPM unit 190 and writes the calculated contents into the RAM. 120 at step S21 in the flowchart of Fig. 13. The look-uptable preparation: unit #12 functions; as the threshold: matrix preparation means for preparing a plurality of: threshold matrices.

The SPM number selecting unit 180 determines an SPM number N<sub>SPM</sub> according to the division coordinates (i,j) given by the SPM address calculating unit 166. The SPM number N<sub>SPM</sub> is equivalent to the table: number. Nt. in the embodiment of Fig. 20 and used toidentify a screen pattern memory corresponding to each: dot offset. A screen pattern memory is selected from the plurality of screen pattern memories included in the SPM unit 190 according to the division coordinates (i,j).

and the corrected threshold values TDc is read out from the the selected screen pattern memory. The corrected was threshold values TDc is compared with the input density value lo to generate a halftone image signal RS.

The structure of Fig. 21 uses a plurality of screen pattern memories, each of which stores corrected threshold values corresponding to each dot offset, and accordingly: does: not require any: correction look-up tables as used in the embodiments of Figs. 14 and 20: The structure of Fig. 14 or Fig. 21; on the other hand; does not require NxN screen pattern memories corresponding to the respective dot offsets, but uses only one screen pattern memory. 31 84140

The above embodiments are only illustrative and not restrictive in any sense. There may be many changes, modifications, and alterations without departing from the scope or spirit of essential characteristics of the invention: notes a subtrail removed fup an Some examples of modification are given below.

anab spamilopt . Tunillerting this

The correction curve shown in Fig. 2(A) or Fig. 15 shows a linear relationship between the input density value to and the number of pixels Mitobe exposed. The principle of the present invention is also happlicable a towar mon-linear melationship expressed by a curve M=f(lo) as shown in Fig. 22. When the correction curve includes a non-linear relationship as shown in Fig. 22, the process of step S12ain the flowchart of Fig. 10 determines the number of pixels M to be exposed corresponding to the input density value to by the function M=f(lo). In accordance with a concrete procedure; the corrected density value Ic is set to be greater than an M-th: lowest/value among Mt pieces of threshold values; which correspond to Mt pixels existing in a halftone dot area. Alternatively, the correction of threshold values is implemented by correcting threshold values up to an M-th lowest value among Mt threshold values, which correspond to Mt pixels existing in a halftone dot area to be less than the input density value lo: This method would generate: a halftone dot having a desired dot percent of M/Mt corresponding to the input density value in each halftone dot area/decidence, polind asider quisical risk

(2) The principle of the present invention is applicable to the Rational Tangent Method as well as the Irrational Tangent Method described above. When applied to the Rational Tangent Method, at least either of an input density value and a threshold value is corrected to generate a halftone dot having a desired dot percent corresponding to the input density value in each halftone dot area, thereby reproducing a desired tone corresponding to the input density value. At they are appropriately and another DECEMBER OF THE The TON SE

Although the present invention has been described and illustrated in detail; it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope

of the present invention being limited only/by the terms unit of the appended claims.

this, is stored ag of the suit.

#### Claims

- ne irruptive of FF 21 in a line 1. Asmethod of:comparing multi-tone image:data with 45. a threshold value to generate a halftone image signal representing an on/off state of each of pixels. arranged in lattices on an image plane, and forming a halftone dot in response to said hälftone image 10 signal in each halftone dot area which is repeatedly arranged to:formian array of halftone dot areas on income said image plane, said method comprising the step A 😘 THE BOOM OF SAR BETT ofits rains tri olah iri gue of exclusion 175 ya 5. 5 (a) correcting at least either of the multi-tone simage data and the threshold value so that a 🐠 halftone dot is formed in said each halftone dot area to have gasdesired halftone dot percentmids
- to prilon our bestewn ning 200 in Fig. 2. A method in accordance with claim-1, wherein said step:(a)/includes/the steps of: and of author discisor a prerayor reseased to eleiphic eni. (b) determining an offset for said each halftone or dof area/including all subject pixel to be procedured. TEE essed, as a function of a resolution of the pixels as well as a screen ruling and a screen angle set which define the array of halftone dot areas on a otherimageoplaneposaid-coffset representinguat 30 deviation of appredictermined reference point of agasaid each halftone dot area from the pixel late my tices; and to so of leads in I surely yrished better No (c) correcting at least either of the multi-tone simage data; and the threshold value according. 35 haltone dot area. Alternatively, steamed by another threshold values is implemented by correcting

specified by the multi-tone image data.

- 3. A method in accordance with claim 2 further com-Prises, the step of announced wastes and step of the s erti napreparing: applurality.iof: correction look-ups 40 tables with respect to a plurality of combinations of the screen ruling: the screen angle, the resolution of the pixels, and the offset, said plurality of correct tion look-up tables being adaptable to be used to: performs said recorrecting eat said step (c); and 45 wherein . It as bordest the table and . Als root and - wsaid step (c) includes the steps of The real m their selecting rome of the plurality of corrections look-up tables according to the offset, and it was group correcting one of the multi-tone image data. 50 and the threshold value based on the selected correction-look-up tables.nothant a me a devictioner producing a feel disonal, responding the
- 4. A method in accordance with claim 2, wherein said step (a) further comprises the step of:

  preparing a plurality of corrected threshold matrices with respect to a plurality of combinations of the screen ruling, the screen angle; the resolution of the pixels, and the effset; and wherein

- in said step (c) includes the steps of the selecting one of the plurality of corrected threshold matrices according to the offset; and the matrices according to the offset; and the matrix reading out a corrected threshold walue from the corrected threshold matrix thus selected.
- 5. A method in accordance with claim 1, wherein said desired halftone dot percent corresponding to multi-tone image data to is given by M(lo)/Mt, where M(lo) denotes the number of pixels to form the halftone dot in said each halftone dot area, and Mt denotes a total number of pixels in one halftone dot area.

  Wherein said step (a) includes the step of correcting the multi-tone image data to be
  - correcting the militi-tone image data to be greater than an M(lo)-th lowest value among Mt threshold values corresponding to Mt pixels existing in said each halffone dot area.
- 6. Aimethod in accordance with claim 1, wherein is a said a desired halftone dot i percent foome and sponding to multi-fone image data le is given by M(lo)/Mt/where M(lo) denotes the number of pixels to form the halftone dot in said each halftone dot area, and Mt denotes a total number of pixels in one halftone dot area; and wherein transport and attached and the step of a spin and M(lo)-the lowest values among the dewest through and M(lo)-the sponding to Mtpixels existing in said each halftone in the sponding to be less than the multi-tone inhage data as a lonioetro MSS end bas oct values and see the said security and as out on the spin method and a secure with as out one of the security and a sout on the security and as out of the security and the spin method and the spin method
- Arrapparatus for comparing multi-terre image dataes as with a threshold value to generate a halffone image 30% signal representing an on/off state of each of pixels arranged in lattices on an image plane, and forming ashalftones dots in vesponse to said halftone image sees signal inteach halftone dot area which is repeatedly 1938s arranged to form an array of halftone dot areas on and the image plane, said apparatus comprising 98 edu mont themia threshold memory for storing the threshold mon value representing a shape of a malftone dotwood according to an image idensity, and no increased side tion Acorrection Imeans ifor Correcting at Heast 1989 either of the multi-tone image data and the threshold value so that a halftone dot is formed in said - 121 each halftone dot area to have a desired halftone elast dot percent specified by the multi-tone image data. At 15/19 thi esh**o**la mavices. . .
- 8. Arrapparatusin accordance with claim 7, wherein it said correction means comprises: 4 regroup 14.2 to offset calculating means for determining an 32.3 offset for said reach halftone doft area individing at 12.3 subject pixel to be processed as a function of a resolution of the pixels as well as a screen ruling and a 32.3 screen rangle which define the array of halftone dot 12.3 areas on the image plane, said offset representing 2.3 a deviation of a predetermined reference point of 192

5

10

15

said each halftone dot area from the pixel lattices; and

correction executing means for correcting at least either of the multi-tone image data and the threshold value according to said offset.

An apparatus in accordance with claim 8, wherein the correction executing means comprises:

look-up table preparation means for preparing a plurality of correction look-up tables with respect to a plurality of combinations of the screen ruling, the screen angle, the resolution of the pixels, and the offset, said plurality of correction look-up tables being adaptable to be used to correct the multi-tone image data;

selection means for selecting one of said plurality of correction look-up tables according to the offset calculated by the offset calculating means; and

means for correcting the multi-tone image data based on the correction look-up table selected by the selection means.

10. An apparatus in accordance with claim 9, wherein

said desired halftone dot percent corresponding to multi-tone image data lo is given by M(lo)/Mt, where M(lo) denotes the number of pixels to form the halftone dot in said each halftone dot area, and Mt denotes a total number of pixels in one halftone dot area; and wherein

said look-up table preparation means includes:

means for obtaining corrected multi-tone image data Ic for each of the multi-tone image data Io, the corrected multi-tone image data Ic being set to be greater than an M(Io)-th lowest value among Mt threshold value corresponding to Mt pixels existing in said each halftone dot area; and

means for registering relations between the multi-tone image data lo and the corrected multi-tone image data lc into said plurality of correction look-up tables.

11. An apparatus in accordance with claim 8, wherein the correction executing means comprises:

look-up table preparation means for preparing a plurality of correction look-up tables with respect to a plurality of combinations of the screen ruling, the screen angle, the resolution of the pixels, and the offset, said plurality of correction look-up tables being adaptable to be used to correct the threshold value;

selection means for selecting one of said plurality of correction look-up tables according to the offset calculated by the offset calculating means; and

means for correcting the threshold value based on the correction look-up table selected by the selection means. 12. An apparatus in accordance with claim 11, wherein special desired halftone dots percent corresponding to multi-tone image data: losis given by M(lo)/Mt; where M(lo) denotes the number of pixels to form the halftone dot in said each halftone dot area, and Mt-denotes a total number of pixels in one halftone dot area; and wherein area.

reparation means includes: table preparation means

means for determining corrected threshold values by setting the lowest through an M(lo)-th lowest values among Mt threshold values corresponding to Mt pixels existing in said each halftone dot area to be less than the multi-tone image data lo; and

means for registering relations between the multi-tone image data lo and the corrected threshold value into said plurality of correction look-up tables.

13. An apparatus in accordance with claim 7, wherein said correction means further comprises:

offset calculating means for determining an offset for said each halftone dot area including a subject pixel to be processed, as a function of a resolution of the pixels as well as a screen ruling and a screen angle which define the array of halftone dot areas on the image plane, said offset representing a deviation of a predetermined reference point of said each halftone dot area from the pixel lattices:

matrix preparation means for preparing a plurality of corrected threshold matrices for a plurality of combinations of the screen ruling, the screen angle, the resolution of the pixels, and the offset, said plurality of corrected threshold matrices being stored in said threshold memory and adaptable to be compared with the multi-tone image data so that a halftone dot is formed in said each halftone dot area to have a desired halftone dot percent specified by the multi-tone image data;

selection means for selecting one of said plurality of corrected threshold matrices according to the offset calculated by the offset calculating means;

means for reading out a corrected threshold value from the threshold memory selected by the selection means; and

comparison means for comparing the corrected threshold value read out from the selected corrected threshold matrix with the multi-tone image data, thereby generating the halftone image signal.

14. An apparatus in accordance with daim 13, wherein said desired halftone dot percent corresponding to multi-tone image data to is given by M(Io)/Mt, where M(Io) denotes the number of pixels to form the halftone dot in said each halftone dot area, and Mt denotes a total number of pixels in one

45

15

ន្ទ . ខុស Liedu ( ។ ទី១ . ១៩៩) ទាន់ក្រុមប្រជាពេល មាន មាន

24

fings in the model absent pathodoxed modeled to the work repeat to off-good per to render to see teleficial an originable on clear telefores mu

An applicable meconican whendrigh 9 viral 10 mg/meconication of the confection remains in the confection repair von magnitude for producting a pilotetig or protection workup tathes with respect to a pilotetig or portection workup tathes with a cross or it is the offer really pilotetic or properties.

1. The offer reall planetty of confection remains the process of the confection of the production of the confection of the c

selection is early unitable, one of said principle of octrebon policipo tables according to the offent culouteted by me offent calculating resentand

meand for contact by me multi-tone image data based on the correction took-up table or leaded by the selection means.

said look-up table preparation means inclupes:

means for obtaining corrected multi-tone image data to for each of the multi-tone image data to, "the currected multi-tone image data to being set to being set or being sate to being among that this each value corresponding to Mt pixels existing to said each halitone dot area, and

means for registering relations between the multi-tone image data to and the poneutation of correction topic image data is to said pluration of correction topics.

17. For expecture in accordance with claim 11 whellen are consented and executing means for present nother cattle or pulsation in seria for presenting a countility of numerity is below taking with a countility of numerity is something of the virtamental present or a numeral ties something, it is resolution in the eventual and the countility of countility of countility is something the value of the virtamental presentation in the virtamental virtamental virtage.

saturation in same or acting and of such plumery or activation works the test as activation and the present of the officer of the region and mulairon and

THE STATE OF A CONTRACT SET OF STATES WAS A CONTRACT OF STATES OF

halftone dot area; and wherein in the suistable of the constant said matrix preparation means comprises:

means for correcting the lowest through an M(lo)-th lowest values among Mt threshold values corresponding to Mt pixels existing in said each halftone dot area to be less than the multi-tone image data lo, to thereby obtain corrected threshold values to be stored in said plurality of corrected threshold matrices.

early for the first on the first one first on the first one first one

recurs for regime of stating by less me to the same stating of the same state of the

 An application in accordance, with piece 7, inclairs in paid on applications makes wither comprises.

The process of the authors of the process of the pr

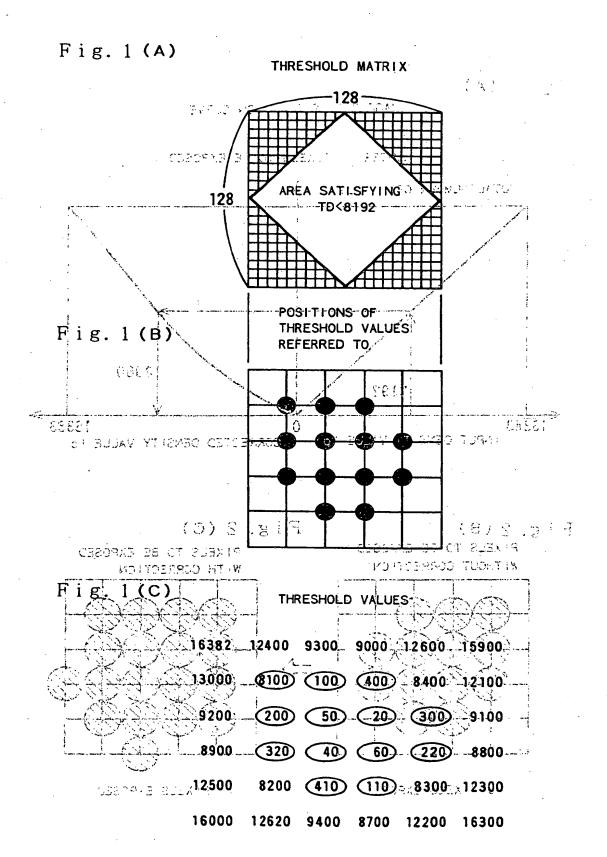
a grincopac not maken noncereta xmamical preparation grandle included considering to the screen rating and computations of the screen rating, the screen rating of considering and the offset, and the resolution of the phasis, and the offset of concerns and solutions and adaptation of the context and threshold it amount and adaptation of the context and each national to a national of the context of the context

sensotion in a to selecting on a said plurally of norm is an incidence accounting to the other of the state of the sense of the state of the sense.

tiodule, whereous him grower is mean 45° and yours of summary because it is not only allow on the contract of the contract of

Fig. 45 (1) communities to the control of the contr

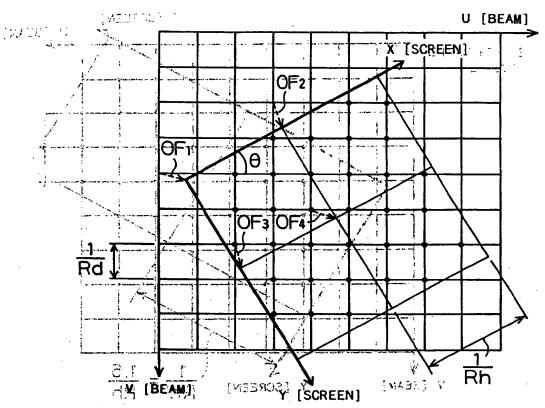
HAR THE PORT OF BUILDING STOP FROM D



LISTAM GLIOFER IN Fig. 2 (A) IMAGE DATA CORRECTION CURVE NUMBER OF PIXELS TO BE EXPOSED TOTAL NUMBER OF PIXELS ALL REFERRED 8900 8192 16383 16383 INPUT DENSITY VACUE CORRECTED DENSITY VALUE IC Fig. 2 (B) Flig. 2 (C) PIXELS TO BE EXPOSED PIXELS TO BE EXPOSED WITHOUT CORRECTION WITH CORRECTION THRESHOL 00:6 0045 13EPIXELSE EXPOSED ( 11 0008 18 PIXELS EXPOSED

16000 12500 9401 0700 2204 1,000

Fig. 3



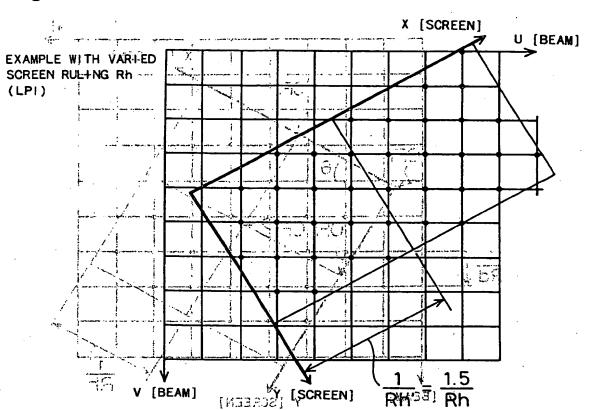
a.sia Fig<sub>M40</sub> o U [BEAM] R CITUUGSTR X [SCREEN] DF EXAMPLE WITH VARIED OF OUTPUT CEVE SCREEN ANGLE 0 [DESPIRED] Y

V [BEAM]

Y [SCREEN]

8.818

Fig. 5



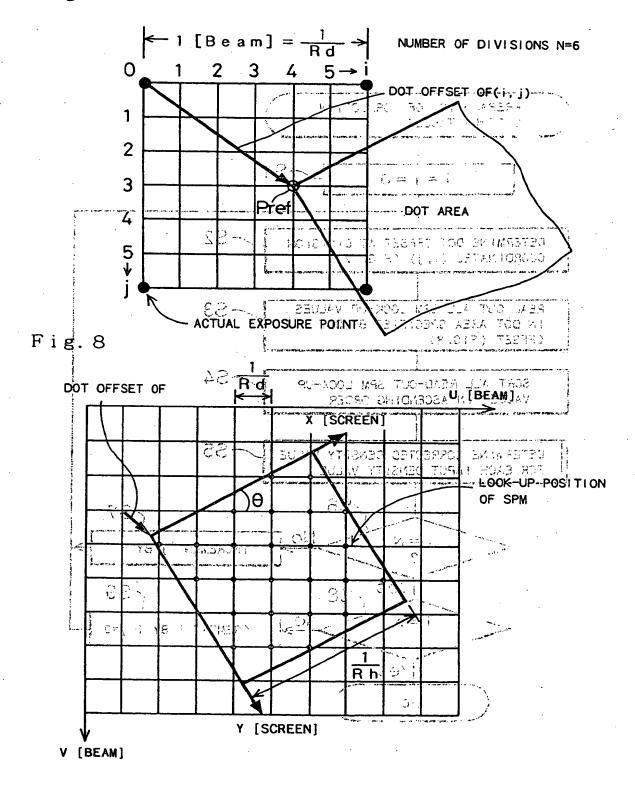
Y [SCREEN]

BATTER Y

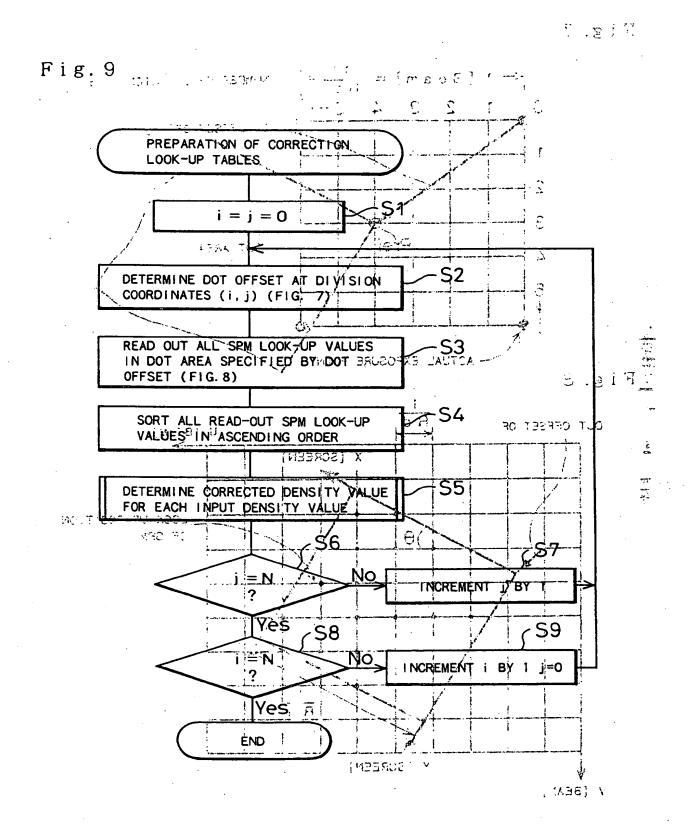
V [BEAM]

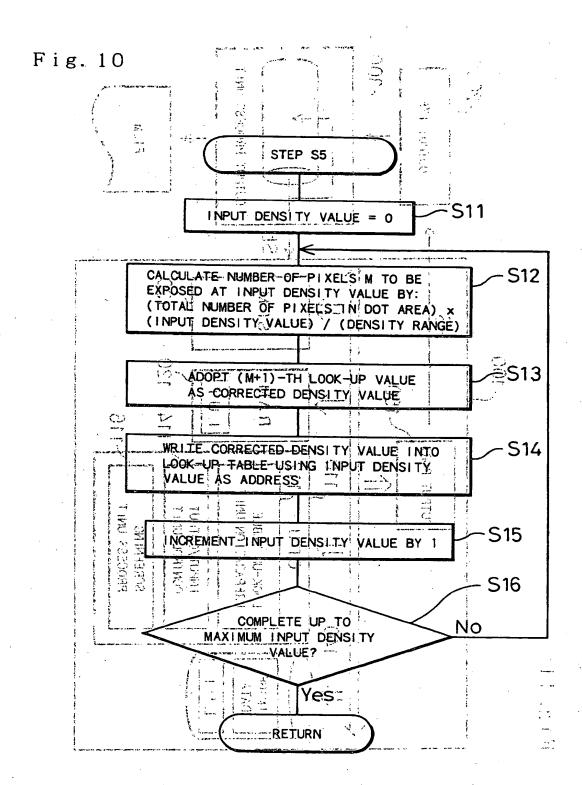
V.3002)

Fig. 7

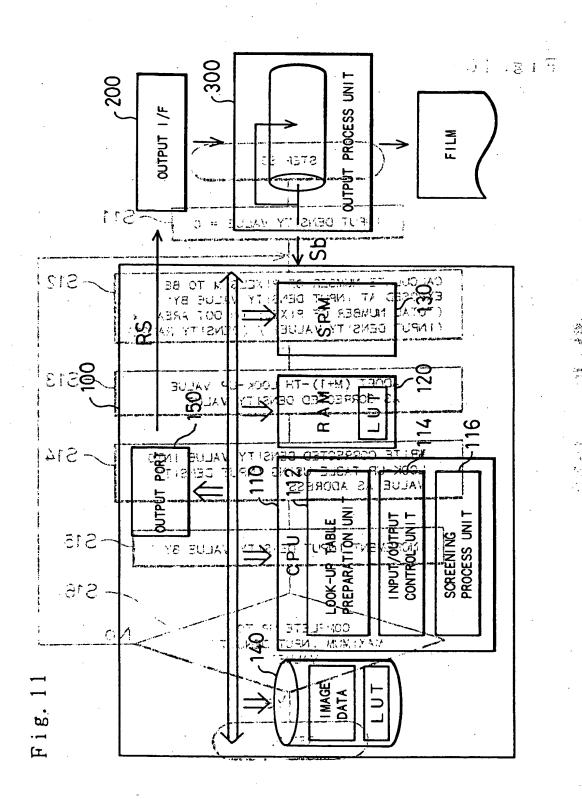


#### EP.0.7311597.A2:





## EP-0 731 597 A2



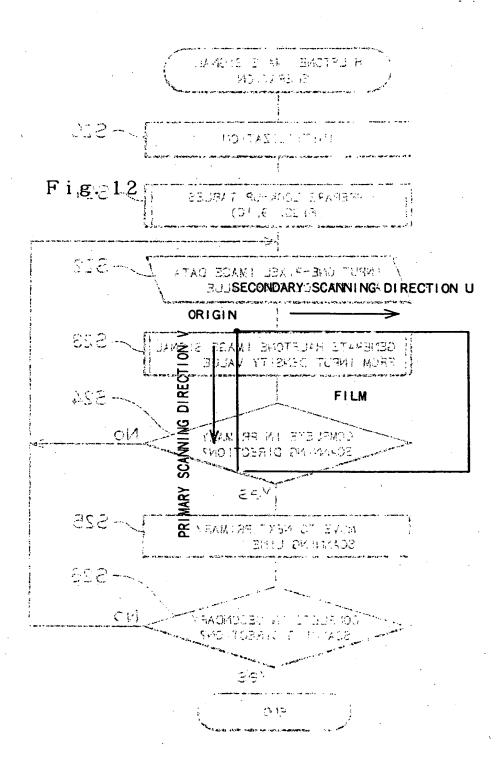


Fig. 13

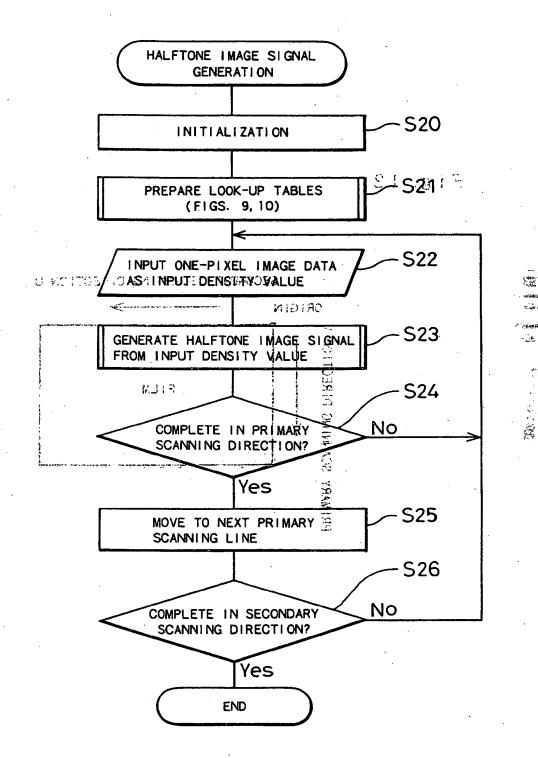
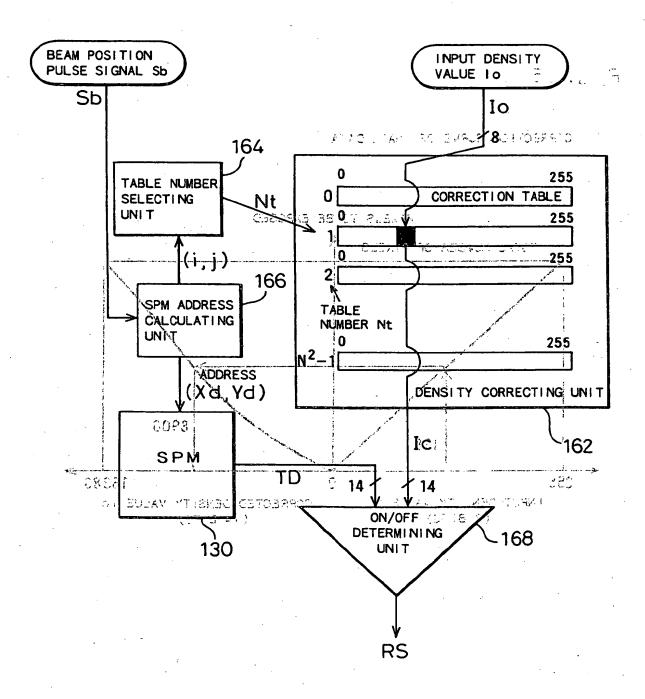


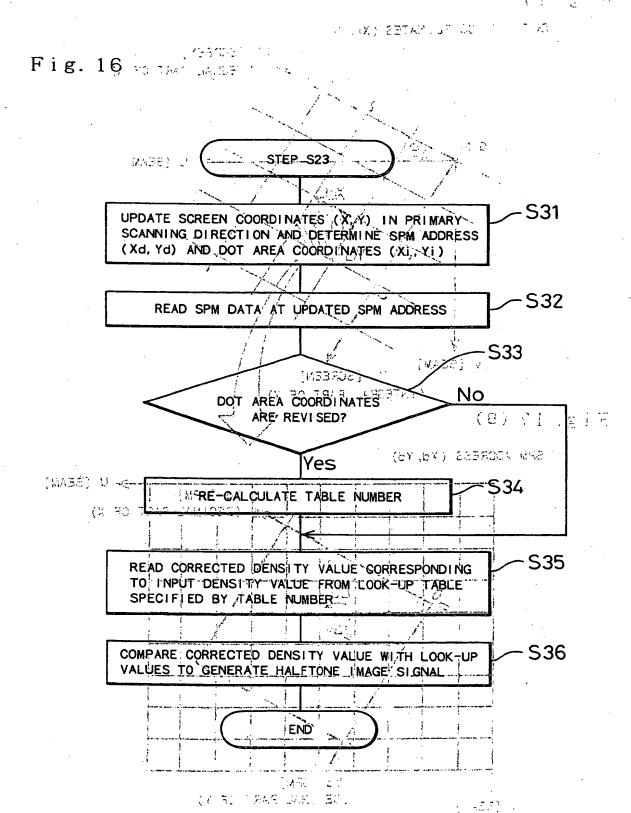
Fig. 14



## EP-0731/597-A2

"1 第1月

BEW POSTION TC1961. PUL! E STONAL So BUDAY Fig. 15 ा CORRECTION CURVE OF IMAGE DATA 481 255 TABLE INUMERS BUBAT MO TOERSOO SELECTING PI XELS TO BE EXPOSED 361 SPM ADDRESS **CULATING** NUMBER NI CRESS (bY TY CORRECTING UT 8900 59 128 SPA 255 16383 INPUT DENSLIY\_YAL'UE Lo. CORRECTED DENSITY VALUE IC (8 BITS) 370 (810 (14"8tTS) ET RMINING 891 095 \_ (

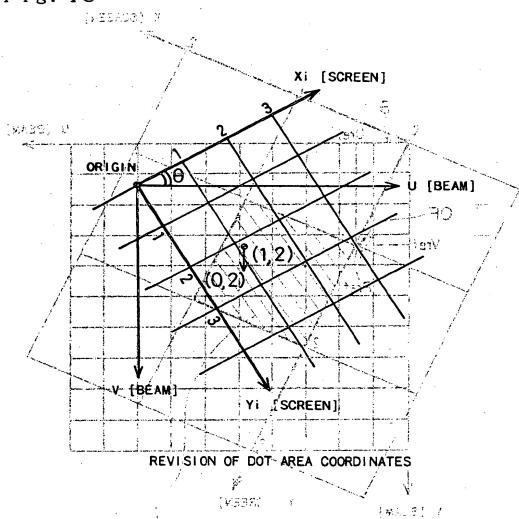


#### ER 0:731:597: A2

Fig. 17 (A)

DOT AREA COORDINATES (XI, YI) Xi [SCREEN] (INTEGRAL PART OF X) ORIGIN U [BEAM] TE2-BOAPHING INTE SBAG 532 SEE ADDRESS READ SPM DATA [MA38] V 533 Yi-{SCREEN] ARABIOOF X374 Fig. 17 (B) REVISED! SPM ADDRESS (Xd, Yd) 29Y 🗩 U [BEAM] 🕸 \_Xd-[SPM] -(DECIMAL-PART OF X) ₹833 × BRAD CARRE 383 COMPARE Yd [SPM] (DECIMAL PART OF Y) V [BEAM]

Fig. 18



US NASA STOO 9 ED BY DOT AREA DUSSONMATES (23 YO)=(0,1)

Fig. 19

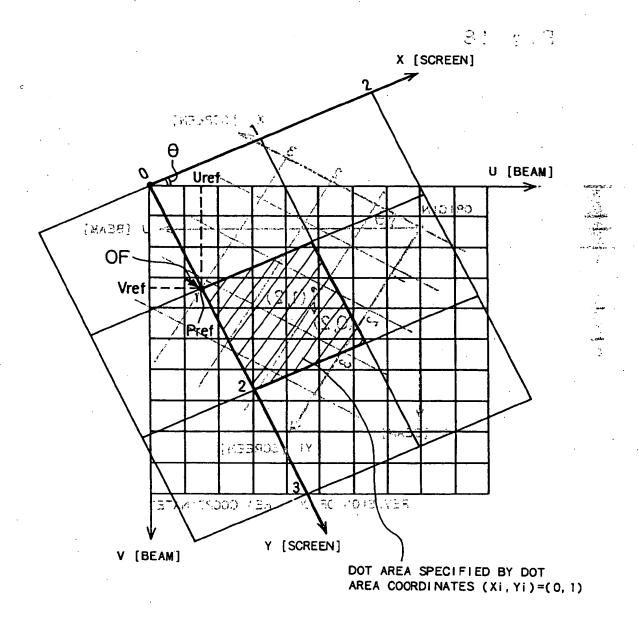
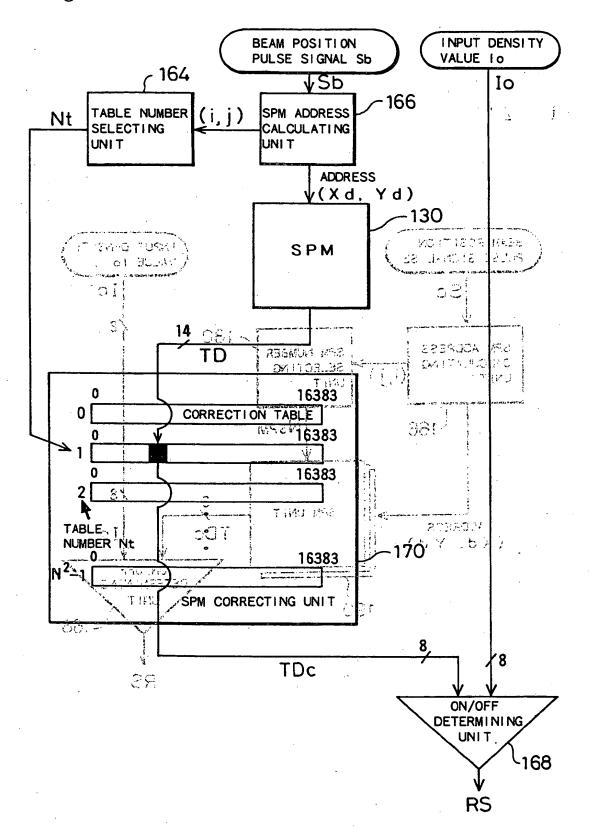
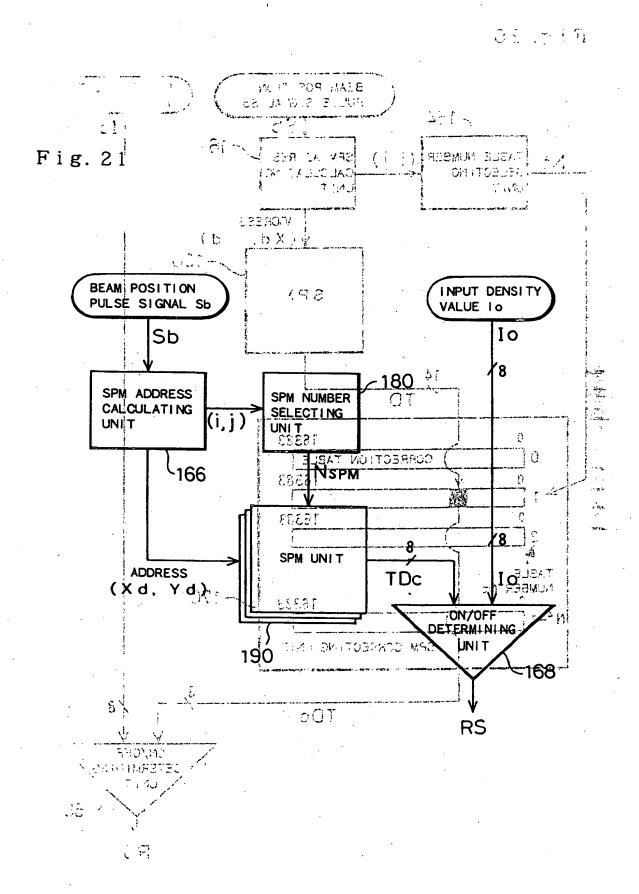
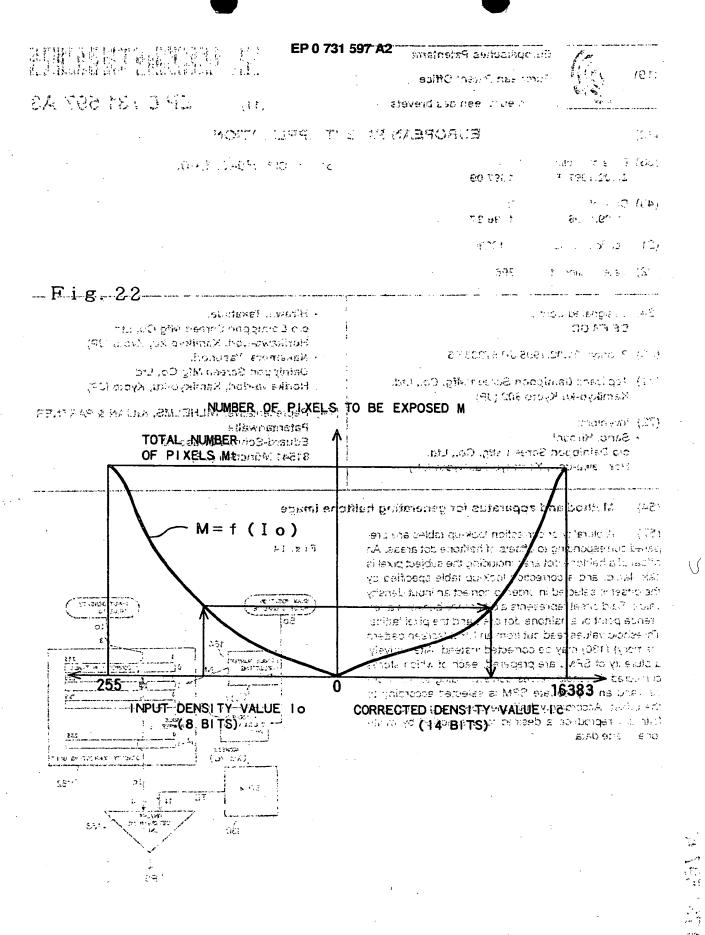


Fig. 20



#### ER 00731 597, A2





(19) **(**19)

Europäisches Patentamt

**European Patent Office** 

Office européen des brevets



(11) **EP 0 731 597 A3** 

(12)

## **EUROPEAN PATENT APPLICATION**

ear too fot off

(88) Date of publication A3: 26.02.1997 Bulletin 1997/09

(51) Int. Cl.<sup>6</sup>: **H04N 1/405** 

(43) Date of publication A2: 11.09.1996 Bulletin 1996/37

(21) Application number: 96102365.2

(22) Date of filing: 16.02.1996

(84) Designated Contracting States: **DE FR GB** 

(30) Priority: 21.02.1995 JP 57933/95

(71) Applicant: Dainippon Screen Mfg. Co., Ltd.
Kamikyo-ku Kyoto 602 (JP)

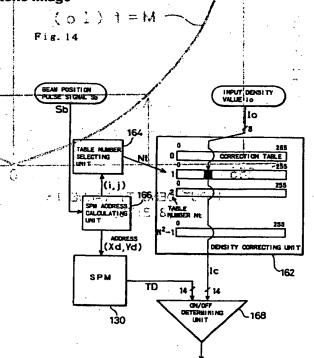
(72) Inventors:

Sano, Hiroshi,
 c/o Dainippon Screen Mfg. Co., Ltd.
 Horikawa-deri, Kamikyo-ku, Kyeto (JP)

- Hirawa, Takahide,
   c/o Dainippon Screen Mfg Co, Ltd
   Horikawa-dori, Kamikyo-ku, Kyoto (JP)
- Nakamura, Yasunori,
   Dainippon Screen Mfg Co, Ltd
   Horikawa-dori, Kamikyo-ku, Kyoto (JP)
- (74) Representative: WILHELMS, KILIAN & PARTNER
  Patentanwälte
  Eduard-Schmid-Strasse 2 3 81541 München (DE) 2 9 30

(54) Method and apparatus for generating halftone image

(57)A plurality of correction look-up tables are prepared corresponding to offsets of halftone dot areas. An offset of a halftone dot area including the subject pixel is calculated, and a correction look-up table specified by the offset is selected in order to correct an input density value. Said offset represents a difference between a reference point of a halftone dot area and the pixel lattice. Threshold values read out from an SPM (screen pattern memory) (130) may be corrected instead. Alternatively, a plurality of SPMs are prepared, each of which stores corrected threshold values corresponding to each offset, and an appropriate SPM is selected according to the offset. Accordingly, halftone dots are generated to: faithfully reproduce a desired tone-specified by multitone image data.





## EUROPEAN SEARCH REPORT 4

Application Number EP 96 10 2365

A CONTROL OF THE PARTY OF THE P

1 

Burry & Char Passagent

ategory	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim.	CLASSIFICATION OF THE APPLICATION (Int.CL6)
X	W. F. SCHREIBER "Fundamentals of Electronic Imaging Systems"	1,7	H04N1/405
	1986, SPRINGER-VERLAG, Berlin (DE) pages 160-183		
Ą	XP002020421	11	73%
	* page 162, paragraph_Bpage 167, line 4	*	<b>デガーター、</b> - 50 - > 1 - 1 <b>00</b> 2
<b>X</b> 14 37	EP-A-0 334 518 (CANON K.K.)  * column 12, line 36 - line 58 *  * column 20, line 16 - column 21, line 13		्राप्तक शत् क्षिणा कथा गुरू केरा छ। सर्वे केड क्षेत्र करा चार चार स
71.95 V	Inventor Delabastits, Paul Lie Agia-Ca		CORRESPONDED LA SECTION DE SECTIO
A	EP-A-0 533 593 (EASTMAN KODAK COMPANY)  * page 6, line 13 - line 54 ***  * page 16, line 30 ** Aine 44%*	2,3,8,9	ar hweed her Fight one each IF Fight Mental (FR)
A	EP-A-0 141 869 (DRING. RUDOLF HELL GMBH)  * page 13, line 4 - line 20 *	) <b>4,13</b> ,2 5.	p wrote wood essent it.
	- The state of the	,	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
	ice naving restricted aensity resolution.	ide tilg devi	H04N
Alrebey For ea ruided Al <b>ebe</b>	if the restrict our design of the particular specific contents of the specific contents of the specific contents of the specific and the specific contents of the specific content of the specific con	aring marge Hazses Tr Rediadi, man Hase If The	und intereur Alle erst in de Bernellings bedalten er well so almass talle aldarum indesen s mass misponsem as Tillena
ici sia	•		
	The second secon		
	The present search report has been drawn up for all claims		
	The present search report has been drawn up for all claims		Executation Roeck, A